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Seismic Data Acquistion System for Navy Oceanographic Measurements

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Foreword

In the ocean, the water comprises but one tenth of one percent of the radius of the earth. It is inevitable that the material underlying the ocean strongly affect phenomena occurring in the water column. Consequently, the Navy is vitally concerned with the solid earth beneath the sea. The region below the ocean floor is studied preponderently through indirect means such as geochemistry and geophysics. Seismology provides the most direct and economical means of investigating these inaccessible regions. Exploration type reflection seismology, using digital methods recently developed by petroleum and coal explorationists and engineering geophysicists, provides the most lucid view into the ocean bottom of any presently available method. This report summarizes the results of an investigation of commercially available reflection seismic equipment and sets forth a design for a complete, technologically advanced, digital seismic data acquisition system. Sample sets of technical specifications are included.

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Executive summary

To carry out present and foreseeable missions involving the collection of seismic and seismo-acoustic data, it is urgent that the Navy's present worn and obsolete analog acquisition equipment be replaced by a new and expanded suite of state-of-the-art seismic instrumentation. New system capabilities should include simultaneous digital recording of both single and multichannel data, with read-after-write analog graphic display of both. A new signal source should consist of an air-compressor-driven water gun system. The instrument/recording laboratory should be housed in a custom van; the self contained air compressor should be mounted on its own skid in a protective cage or shed; and the streamer should be carried on a winch that provides both protection during transport and storage and efficient handling during at-sea operations.

Single channel methods are required for deep-ocean work, as well as for much normal underway geophysics, and such capabilities must be retained. However, a 48-channel digital data acquisition system capable of recording both standard exploration and high-resolution frequencies is urgently needed for use in shallow and medium depth waters, especially nearshore on continental shelves, slopes, and rises, and in certain other bottom-limited areas; this system should have the additional capability of recording signals from the closest hydrophone group as a virtual single channel record. In all cases, the digital recording on magnetic tape should be followed by read-after-write graphic printout for underway interpretation of single channel data and for monitoring multichannel data collection. The multichannel systems which have long been the standards in the petroleum exploration industry are not capable of meeting the high sample rate and operational flexibility requirements stated here; however, a recently developed system can meet these requirements. Also, display capabilities presently being developed will give the required real-time graphic printout needed for Navy applications.

The entire data acquisition system, as well as peripheral navigation, streamer positioning and monitoring, and communication equipment is housed in a climate-controlled, custom-fitted van. This configuration allows the system to be used on ships of opportunity as well as facilitates its use in less conventional applications. It also protects the instruments during operations, transportation, and storage; provides climate controlled storage of data; facilitates maintenance of the instrumentation; and ensures that the inventory of spare parts is always accessible.

For multichannel seismic operations using standard near-surface signal sources and streamers, physical constraints and current economic realities are such that operations are practical over a range of water depths extending from somewhat less than 100 m to only a little over 1 km. The frequencies of interest range from less than 20 Hz to approximately 1 kHz. Therefore, depending upon the depth and purpose at hand, aliasing considerations and

the geometry of the data collection operations are such that hydrophone streamers require group spacings selectable from among 6.25-, 12.5-, and 25-m intervals, with corresponding length of streamer ranging from 300 m, to 600 m, to 1200 m. One hydrophone streamer design capable of meeting all these requirements has its hydrophones arranged in two independent, full-length sets: one set has groups of five very closely spaced hydrophones to give ''point'' groups for use with high frequencies and very oblique reflection angles, but groups in the other set are comprised of more widely separated units for lower frequencies and nearer vertical reflections. Depth control vanes control streamer towing depth. Built-in compasses, depth sensing transducers, and conductors in the active sections allow shipboard monitoring of streamer depth.

A winch and streamer handling/storing system provides convenience and easy handling by small crews during operations as well as protection to the streamer during shipping and storage.

New signal sources consisting of water guns driven by an air compressor (which can also drive air guns) give an unusually simple, broadband signal that has energy approaching that of air guns; these signal sources also carry depth sensors and source-signature hydrophones.

The air compressor best meeting foreseeable needs and constraints is a self-contained system mounted on a skid within a protective cage. It carries its own diesel power plant with fuel tank, integral cooling systems for both engine and compressor, an air receiver tank, controls, and a built-in bilge with scupper.

Successful application of this system calls for continuous, extremely precise knowledge of the ship's absolute position and for constant knowledge of source and streamer location and configuration. Only the state of the art in navigation equipment and technique suffices. Since marine multichannel seismic data collection requires so much greater precision in navigation than is the case in practically any other ship operation, the navigation available from the ship's bridge is almost never as good as is required. Therefore, it is imperative that the navigation be performed by the operators of the seismic system and that the best navigation equipment available be provided to them. At this time, it appears that the Global Positioning System has the potential for solving the navigation problem, but that matter is beyond the scope of this report. However, it is important to reiterate the absolute criticality of navigation of this caliber to multichannel seismic work.

Preface

To a seafarer who has been out of sight of land for many days, weeks, or even months, the World Ocean may seem infinite in both extent and depth. However, on the planetary scale, this water comprises only a thin film over a body that is overwhelmingly solid earth material. While that film of water is so important in human affairs that many of us devote our lives to working, studying, and playing on and in it, we are all still constrained by the fact that less than one-tenth of one percent of the depth of material that lies beneath us is ocean. Any serious scientist or researcher will recognize that the remaining 99.9 percent must have far-reaching and profound effects on what takes place in the water, regardless of the phenomenon in question.

So it is that in discharging its many and diverse responsibilities, the Navy is unavoidably concerned with this solid earth. That vital concern begins with understanding the nature and nuances of the ocean bottom, which so intimately and pervasively intertwines with the lives of all who go to sea. But the influence of the bottom does not stop at the bottom; it only begins there. In large measure, the properties and phenomena that occur in the water are determined by the nature of the thousands of meters of material beneath the ocean floor. Therefore, it is necessary for the Navy to study the solid earth to depths far beneath the bottom to understand and cope with the problems encountered in the watery domain.

Systematically deciphering the properties of the subterranean earth is not easy, and it is especially difficult for the regions beneath the sea. Clearly, few investigations can be conducted by direct sampling techniques. Most properties must be deduced from data such as that derived from geophysical and geochemical measurements. In this milieu, the science of seismology plays a premier role, using the full range of elastic waves to look into the solid earth in a way analogous to that of an x-radiologist using electromagnetic waves to examine the interior of a living body, or an acoustician or sonarman using sound pressure waves to look at the undersea world. The most sophisticated, directly useful method for mapping the subbottom and deducing its elastic and acoustic properties, as well as making estimates of its other physical parameters, is the reflection seismic technique, especially in the stages of perfection to which it has been brought by workers such as those in the petroleum and coal exploration and reserve evaluation community during the last two or three decades.

It is to take advantage of recent advances in this field that the digital seismic data collection system described in this report was designed. Essentially all of the commercially available digital exploration and engineering type seismic equipment made in the U.S. was considered and the most likely candidate components evaluated in the light of their capabilities and economic realities. The system that evolved is a system that represents modern technology and is a system that offers the maximum practical versatility. It should not become obsolete for at least a decade, and even when its technology is superceded by new developments, it should still economically provide a plethora of highly useful data.

Acknowledgments

Several people recognized as expert in the fields of engineering geophysics, petroleum exploration, general high-resolution seismology, and research/survey-oriented deep ocean reflection profiling work were consulted for their experience and recommendations as well as information about sources of equipment. Their assistance is greatly appreciated.

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The analysis and evaluation of water gun applications benefitted greatly from the expertise and experience of Mr. Robert A. Carter, Jr., manager of Amoco Production's marine operations, New Orleans, and of Dr. Gerald H. F. Gardner, co-director of the University of Houston's Allied Geophysical Laboratory. Conferences with Mr. Adrien Pascouet of Seismic Systems, Inc., Houston, and Mr. James B. Hambrick of Hamco Instrument and Machine, Houston were also very helpful. Mr. Don Price answered many questions about the engineering and construction of air compressors during a half-day trip through the Price Compressor Company plant in Houston.

During the past several years a number of people have investigated various seismic data acquisition systems, identifying advantageous features as well as pitfalls characteristic of individual systems and components and often writing technical specifications that provided guidance for those contained in this report. These people include Messrs. William Marshall, Walter Johnson, Luther Little, and Charles Orr. The groundwork they laid has been extremely valuable, and their contributions are greatly appreciated. Also, the work done by Mr. Frank Carnaggio in designing the instrument laboratory van and writing specifications for it as well as many other items is gratefully acknowledged.

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Seismic data acquisition system for Navy oceanographic measurements

Introduction

The seismic data acquisition systems presently owned by the Naval Oceanographic Office (NAVOCEANO) and customarily used aboard NAVOCEANO ships, especially the AGORs, have been in service for at least 10 years, and in some instances for almost 20. The technology they are based upon is at least 25 years old. Technically, these systems are still capable of obtaining data of limited usefulness. However, since they lack the benefits of some near-revolutionary developments that have taken place in so-called exploration-type seismology during the last quarter-century, the data collection efforts of the Navy laboratories, such as the Naval Ocean Research and Development Activity (NORDA), are seriously compromised. This report describes a highly flexible, state-of-the-art seismic system that would incorporate most of the latest developments while retaining the desirable features of the old systems.

Major current shortcomings

Possibly the most serious single shortcoming of present standard Navy shipboard seismic systems is that they are strictly analog and have only a graphic output. Therefore, it is impossible to take full advantage of the great strides in data processing that have taken place almost exclusively in the digital mode during the last two decades. It also means that both dynamic range and bandwidth of the signals recorded are severely restricted. Furthermore, all phase and most spectral information are lost. For many purposes, these are problems that impose fundamental restrictions on the usefulness of the data. Thus, with the present systems, the analog variable density records, as made aboard the ship to satisfy the conceptions of the often inexperienced operator as to what constitutes a ''good looking'' record, determine what all future interpreters of that data will have to work with, for all purposes. This represents a severe limitation on what can be done.

A second major shortcoming is that only single channel data collection is possible. While multichannel seismology is a technique that should be applied only when obviously needed (and it is certainly a costly process that falls far short of being a cure-all for seismological problems), its nearly universal adoption and highly successful application by myriad users who must base their choices upon economic rationales clearly indicates the technical and cost effectiveness of the method. In any computation-intensive and computer-competent organization engaged in seismological or acoustic work, attention is irresistibly drawn to the need for such capabilities. When the capability for doing multichannel work is lacking, many avenues of work are denied. It is evident that some of the Navy's needs may well be satisfied by simple single channel seismology, but many more persistent and intractable problems can be addressed only through multichannel capabilities.

Seismic system requirements

A conservative estimate of foreseeable Navy needs in seismic data acquisition capabilities is herein summarized:

1. The Navy needs to have the capability to do both single channel and multichannel seismic profiling, and it is important to be able to do both independently at the same time.
2. It is highly important to generate both digital tapes and real-time graphic records of the data while those data are being collected.
3. It is necessary to be able to record a dynamic range of at least 100 dB with a bandwidth reaching from about 20 Hz to at least 1200 Hz.
4. It is necessary to have sources capable of generating a signal with at least 5.5 bar meter (0–500 Hz) peak pressure level that is flat within 20 dB from 20 Hz to 400 Hz and down no more than 48 dB at 1 kHz.
5. It is necessary that the equipment be reasonably compact, self-contained, operable with a small crew, and conveniently and safely portable from ship to ship.
6. Navigation equipment must be capable of fixing the position of the ship within a few tens of meters at all times and of locating the relative positions of ship, signal sources, and sensors within a few meters; this information must be automatically incorporated into the seismic data.

Single channel vis-a-vis multichannel

The ultimate goal of practically all seismic reflection profiling, whether single channel or multichannel, is to produce what may best be described as a ''migrated, single channel record.'' Stacking multichannel data is merely a technique that

reduces many reflection events taken at different angles from approximately the same reflection point to an equivalent vertical reflection from that point. The purpose is to suppress the effects of the intervening media and to increase signal-to-noise ratio. Essentially, a good stacked record is the equivalent of an idealized single channel profile over the same line. To produce this ideal profile requires a computer, such software as NORDA's DISCO package, and digital data.

Of course, all single channel records, whether stacked equivalents or true single channel profiles, must be migrated to convert two-way reflection travel time profiles into spatial-dimension profiles corresponding in some way to acoustical impedance mismatches related to the geology. This, too, calls for computer assistance and digital data.

A feature of multichannel data that is equal in importance to the signal enhancement/noise suppression characteristics is the capability it gives for determining the velocity structure in the bottom, both vertically and horizontally. In addition to allowing migration of seismic sections, such velocity information is of vital interest for its own sake, especially to the Navy. To collect data useful for velocity analysis, the hydrophone streamer needs to be at least as long as the greatest depth of interest. Thus, on the continental shelves, a streamer about 300 m long is needed. This region contains very fine features calling for the resolution capabilities of high signal frequencies and ¼ msec digital sample intervals. Since most data processors agree that the more or less standard hydrophone group separation of 6.25 m is the maximum that works well, a streamer with 48 point groups spaced 6.25 m apart is about the minimum that can meet requirements. With this digital sample interval and streamer group spacing, it is possible to work with seismic signals having frequencies of 400 Hz, or more, and to receive acoustic waves such as direct water waves up to about 1350 Hz before aliasing problems become intractable. In the bottom, 400 Hz signals give high resolution and reliable penetration to over 200 m in most cases and to more than 500 m in many sediments.

On most slopes and rises, deeper water, thicker sediments, and often coarser structure call for longer streamers and lower frequencies and allow greater sample intervals and group spacings. Here, frequencies below 250 Hz, group spacings of 12.5 m, and 600 m streamers, again calling for at least 48 channels, are the most acceptable compromises for the shallower sections. In deeper areas, frequencies will drop, group spacings can open to 25 m, and streamers of 1200 m are called for. For most Navy purposes, this probably marks the limit of practicality for surface-operating multichannel seismic data collection.

For depths below a kilometer or two, the equipment called for goes beyond anything feasible for compact, portable multichannel systems. Most geological problems can usually be addressed by single channel shipboard systems using sonobuoy techniques to obtain velocity information (and possibly refraction data). If the complexity and importance of the region calls for multichannel methods, then a deep-tow system such as the Deep Towed Array Geophysical System (DTAGS) developed by NORDA should be used; in fact, DTAGS was originally conceived and designed to perform at full ocean depth precisely the functions the surface operating high-resolution system outlined above performs on the continental shelves.

It is mandatory that single channel graphic hard-copy printout always be obtained during operations. These printouts have proven to be adequate for many oceanographic purposes and are essential for underway interpretation, as well as for monitoring data quality. Most experienced interpreters demand such records in addition to any other data that may be available. Therefore, the channel closest to vertical reflection should have an auxiliary output to a line scan recorder, or better, to a matrix printer (as typified by the Printronix, Versatek, and others) that is capable of producing automatic-gain-controlled, variable area, "wiggly line" records similar to those drawn by oscillographic recorders. This printout should be read-after-write, should take its input from the digitally recorded tape immediately after recording, and should operate through its own microprocessor, if such is required. Extensive experience has shown that it is also mandatory to be able to closely monitor even multichannel recording with similar read-after-write visible printout capabilities. In addition, it is highly desirable to have immediate postacquisition processing capabilities and software that perform enough processing to validate data acquisition success and allow underway adjustment of recording parameters.

Digital and analog recording

In addition to being required for the application of computer processing techniques, seismic data must be in digital form to achieve the dynamic range demanded by present-day requirements. Also, both phase and broadband frequencies are best preserved in digital form. The manpower savings possible with predigitized data are often considerable.

However, as alluded to before, seismic data must be in analog form with a specific format to be widely useful for interpretational purposes and, as a consequence, for monitoring purposes. These diverse yet complimentary demands highlight the necessity for both types of record and illustrate why they must be made at essentially the same time.

Dynamic range and bandwidth

All exploration-type analog seismic recording methods have always suffered severe shortcomings because the difference in amplitude of a typical direct wave and the smallest signal of interest is at least 100,000 to 1 and may be on the order of 1,000,000 to 1. Thus, a usable dynamic range of 100 dB is none too large, which makes analog systems unsuitable for

preserving true waveforms. Typically, a digital system with 15-bit analog-to-digital converters and instantaneous floating point amplifiers with 4-bit exponent range are used to accommodate this dynamic range.

Also, Navy interests are pressing in the directions of both higher and lower frequencies. In particular, the acoustic frequencies in the kilohertz range and above are receiving increasingly great emphasis, even in ''seismic'' operations. Thus, it is necessary to work with high-intensity signal in that frequency range and to be able to accommodate a very high dynamic range in recording operations. A ¼ msec sampling interval is close to the shortest currently practical in off-the-shelf seismic instrumentation; however, lying as it does in the frequency range where high-resolution seismics and traditional pure acoustics overlap, this sample interval is particularly useful, and instruments capable of this sampling speed are highly versatile.

The seismic data acquisition system

The data acquisition system is the ''heart'' of the seismograph system and determines the nature of all the other components that will be required. Data acquisition systems evaluated for possible adoption include ''engineering geophysics'' seismograph systems ranging from the simplest single channel units to highly sophisticated, state-of-the-art multichannel (up to~500 channels) systems; petroleum exploration systems used by the commercial explorationists; and ''research'' instruments created and refined in university laboratories.

Systems evaluated were from the following companies:
Bison Instruments, Inc., Minneapolis, MN
Quantum Electronics Corp., Houston, TX
Texas Instruments, Inc., Houston, TX
Gearhart/Geosource, Houston, TX
Input/Output, Stafford, TX
GUS Manufacturing, Inc., El Paso, TX
Teledyne-Geotech, Garland, TX
EG&G-Geometrics, Sunnyvale, CA

Also included was a system assembled by Dr. Thomas Shipley at the Institute for Geophysics at UT, Austin; foreign vendors are excluded.

Of all the systems evaluated, the EG&G/Geometrics ES-2420 was found to come closest to meeting the technical specifications required for our purposes. This system was designed to challenge the Texas Instruments DFS-V which, together with the French Sercel, has long been considered the benchmark of the industry and the system of choice of the vast majority of petroleum explorationists. The ES-2420 matches the DFS-V in essentially all points and exceeds it in a number of areas critical for Navy applications.

Specifically, the DFS-V is not capable of sampling intervals of ¼ msec with large numbers of channels. The ES-2420 takes advantage of the dramatic decrease in the cost of 15-bit analog-to-digital converters and large memory boards that has occurred since the DFS series was designed almost 15 years ago. The DFS-V has one digitizer for the entire system; the EG-2420 uses a similar board for only eight channels, and consequently can, with expander card cage modules, handle literally hundreds of channels at ¼ msec sample intervals. Also, each channel has its own 16,384 sample buffer memory, which allows much useful data manipulation and desirable recording strategies.

The EG&G ES-2420 meets our requirements except for an immediate read-after-write, graphic printout capability. However, EG&G is presently working on that capability, and will soon have a graphic printout capability exceeding the requirements.

Another system with a number of attractive features is the single channel system developed by researchers at the Lamont-Doherty Geological Observatory, the University of Rhode Island, and the University of Texas at Austin. This system is comprised of a string of off-the-shelf Ithaco amplifiers and Wavetek filters of the type widely used by NORDA and NAVOCEANO, feeding into a Masscomp digitizer and thence into a Masscomp 561 minicomputer. Recording is on a digital tape recorder and on a Printronix line printer. The system is software controlled by programs developed by those who assembled the system.

The extensive use of widely available componentry and the often-demonstrated effectiveness of analog single channel systems comprised simply of interconnected groups of those standard components make this an attractive approach to the digital single channel acquisition problem as well. However, there are two serious problems with such digital systems. As Dr. Tom Shipley, now at the University of Texas' Institute for Geophysics and one of the major figures in the development of this system carefully pointed out (personal communication), the software they use is of their own writing, and since it is for strictly research purposes, it is often custom tailored on the spot for the purpose at hand. Consequently, it contains many eccentricities and requires that someone expert with both Masscomp computers and the entire suite of acquisition software be on hand at all times. Even though it is set up to provide considerable isolation between system and naive user, it is still not a system that can be turned over to nonspecialized technicians with the expectation that they will be able to routinely collect acceptable data. The second problem is that it is strictly single channel with no capability of being expanded to multichannel. Finally, there is no economic advantage in assembling one of these systems instead of purchasing the basic 4-channel, commercially available, user-friendly EG&G ES2420 system: the costs of the two systems are comparable. Nor is there any significant advantage in having the Masscomp computer for shipboard data processing. The post acquisition processing package available for use with the ES2420 with its Intel 8086 processors does

about as much as can be accomplished on the Masscomp when the latter is serving in a dual mode. Those requiring shipboard processing would probably do well to bring aboard their own undedicated computer and use it independently of the data acquisition operations rather than risk interference with such operations.

It is particularly important that a sizable cadre of operators and potential operators of the multichannel system receive detailed instructions in its use and in troubleshooting malfunctions.

A hydrophone streamer for a multichannel system

Except for the fact that the streamer contains two independent sets of hydrophones, both of which have hydrophone groupings different from that previously used by NAVOCEANO and NORDA (and with corresponding changes in wiring and and connectors), the hydrophone streamers specified are quite similar to those used satisfactorily by the Navy for many years. As noted before, the streamers contain a set of hydrophones with sets of five T-2 type hydrophones arranged in 0.5-m-long "point arrays" with centers at 6.25 m intervals, plus a second set of hydrophones with groups consisting of ten hydrophones arranged in a 6-m-long "baseline array" pattern again having minimum group centers spaced 6.25 m apart.

By using jumper plugs or interface adapters, group spacings can be interchanged among 6.25-, 12.5-, or 25-m intervals. Thus, by changing the number of interchangable active sections, one cable system serves as the sensor array for all operations from 48 channel, ¼ msec, high-resolution work to very low frequency, single channel, deep ocean profiling. Inductive couplers built into the streamer at selected locations and hard wired through dedicated conductor pairs to the recording laboratory allow underway control of hydrostreamer leveler devices ("birds") with matching couplers. Data concerning depth and leveler vane angle are transmitted back to the laboratory from the birds; other couplers and conductors transmit data from fluxgate magnetometer heading sensors ("compasses") and additional depth sensors in the heading detection units.

Note that these specifications do not contain any selection for a hydrophone streamer winch. That lies is an area where the writer does not feel comfortable in writing the specifications.

Signal source

The sparker has been the primary seismic signal source for the Navy oceanographic fleet for decades, and it has a number of extremely attractive characteristics. It would be a definite handicap to be deprived of this signal source, especially as a supplementary source of high frequencies and as a highly reliable, maintenance-free backup for other sources. Its most serious shortcoming is its low signal energy.

Air guns can have very high signal energy, but the preponderant frequencies are quite low except in very small, low-energy units, and signal trains are complicated by bubble pulses and other complexities. All of these factors limit resolution. With air guns, good resolution combined with good penetration requires the use of arrays which include several small air guns for each large air gun to achieve both the bandwidth and the energy needed. Air gun units are typically complex and require constant maintenance. (The new sleeve valve versions appear to be somewhat better than usual in terms of durability, output power, and bandwidth.) Also, handling a large array of air guns is almost impossible without a large crew and a ship equipped with special gear capable of handling heavy, large, awkward arrays. While for some applications air guns seem to be the only viable alternative, for most purposes water guns have enough advantages to make them a distinctly more desirable source and type of mechanism than air guns.

Experience with water guns at NORDA, the Hawaii Institute of Geophysics (HIG), and several oil exploration organizations indicates that about twice as much capacity is required in water guns to generate output power equal to a given volume of air guns. However, the water gun signal lacks bubble pulses and has much better high-frequency characteristics, especially if the gun is kept shallow. A 200 in^3 water gun at about 3 m depth has excellent output up to 400–500 Hz, and significant power to above 1 kHz. Without the long train of bubble pulses the signal is much cleaner and shorter in duration. The signal is very much nearer to the minimum phase pulse or zero phase wavelet so highly desired by data processors and interpreters. Water guns are appreciably safer and easier to handle and use than air guns, and they appear to require significantly less maintenance. Even when multiple guns are used, water gun arrays generally have only about a third as many units as air gun arrays.

Air compressors to power signal sources

Water guns are powered in two different ways. One method is to use compressed air to drive the piston or shuttle. After a shot, the air is exhausted to the atmosphere through an exhaust hose, or into the water. The second method uses a combination of compressed air and hydraulic pressure. The latter way is about twice as efficient as the former and therefore can use a powering system about half the size of systems using only compressed air. However, it is several times as complex and is less reliable. It may also be less durable. Furthermore, it cannot drive the numerous air guns that are in the inventories of the Navy and associated laboratories.

Among air compressors, one particular system has appeared as the overwhelming choice of the exploration seismic community. For driving air guns and water guns, Price Compressor Company units may outnumber all other units in the world combined. These units were originally designed for rental and operation by inexperienced personnel, and are rugged, low stress, exceptionally simple, easily maintained systems. They are self-contained, compact, easily operated, and safe to use.

Manufacturers of compressors considered include Joy, Gardner-Denver, Price, Worthington, Rix, Norwalk, and Mako.

Space considerations

While it is anticipated that the primary platforms used with this equipment will be the AGSs and AGORs, its use will not be limited to these ships. It is important that the equipment be as compact as possible so that various smaller ships of opportunity can be utilized. Therefore, the largest item in the suite, the compressor, will be the limiting factor, and it is especially important to keep its size and weight within reasonable bounds. A package with dimensions of about 7 x 8 x 7 feet high is about the largest that will conveniently fit on the O1 deck of the present AGORs. Weight must not exceed about 6 tons.

A second large item is the hydrophone streamer. The bulkiness of such streamers comprises a major factor limiting the length that can be used on board a given ship. At present, it would be extremely difficult for the AGORs to handle a streamer much longer than a kilometer. The simplest way to store and handle the streamer is to use a dedicated winch that incorporates features to feed out and retrieve the streamer, to provide positive slipring electrical connections, and to protect the streamer from damage when on deck or while in transit or storage.

The data acquisition system takes up little room; most such units are contained in two or three cases the size of large suitcases. The tape recorders ordinarily supplied with such systems also are fitted into similar cases. The graphic recorders/printers are of comparable dimensions.

However, since experience has repeatedly demonstrated that the specialized, very high precision navigation required by multichannel seismic data collection operations must be performed by the scientists collecting that data and recorded directly on the data tapes and records, the navigation system must be located with the data acquisition system. The same is also true of the source and streamer locating and positioning systems. An effective communication system connecting the instrument laboratory with other laboratories and the ship's bridge, fantail, and other laboratories is indispensable.

Protected table space is required for work with charts and graphic records. Maintenance and repair of the instruments also requires table space.

Since large, delicate instrument systems are extremely susceptable to damage and loss of components in transit, shipping such systems is a perennial, serious problem. Also, assembling and disassembling these systems in the field carries a further significant element of risk. Even storage of the equipment in ports often exposes the equipment to the elements and to pilfering. Finally, storage of the equipment at home base calls for dedicated, climate-controlled space wherein it is not only protected but also accessible for maintenance and use.

While few would elect to work in such confines by choice, the foregoing considerations and an extensive body of experience indicates that a dedicated, portable, modular, instrument/recording laboratory or van is probably the only satisfactory method for organizing, housing, shipping, storing, and using such a system. A portable laboratory/van of a type that has proven satisfactory for use on both the AGORs and other oceanographic and geophysical exploration ships is described in an appendix.

Preliminary budget

The following prices are compiled for cost estimations only. They are unofficial quotes from various technical and sales representatives within those companies vending equipment that meets or exceeds baseline requirements, and no negotiation or purchase agreement has been made nor implied.

Air compressor (Price Compressor Company)		\$65K
Water gun, 200 in^3 (Hamco)		\$27K
Seismic data acquisition system (EG&G Geometrics ES-2420, 48-channel)		\$160K
(* 4-channel system: system = ACU w/4 channels (minimum))	\$55K;	
(* 24-channel system: system = ACU w/24 channels (maximum))	\$87K;	
(* 48-channel system: system = ACU w/24 channels + extender module w/three pairs of 8-channel boards.)	\$160K;	
Digital tape recorders (2)		\$50K
Hydrophone streamer system		\$239K
*1 deck leader	\$1.4K	
*1 tow leader	\$10.0K	
*3 25-m stretch sections	\$10.5K	
*30 50-m active sections	\$184.0K	
*point select adapters	\$2.0K	
*active tail swivel assembly	\$5.7K	
*hydrostreamer spare parts	\$5.7K	
*2 depth adapter sections	\$3.0K	
Digital depth monitor system		\$16K
Depth monitor spare parts		\$1K
Streamer leveling devices (birds)(7)		\$28K
Heading sensors (compasses)(5)		\$20K
Cable control electronics		\$15K
Hydrostreamer winch		\$??K
Instrument shelter assembly (8 ft X 20 ft van)		\$60K

Appendix 1: Specifications for seismic data acquisition system

APPENDIX 1: SPECIFICATIONS FOR SEISMIC DATA ACQUISITION SYSTEM

1.0 SCOPE

1.1 This document describes the requirements for a digital seismic data acquisition system for obtaining continuous reflection profile (CRP) and wide angle reflection (WAR) data. (CRP is also referred to as "normal incidence reflection" and "single channel reflection" profiling.)

2.0 APPLICABLE DOCUMENTS

2.1 Not Applicable

3.0 REQUIREMENTS

3.1 System Definition: The seismic data acquisition system shall operate from the Navy's and other oceanographic vessels and will be used to collect seismic data. The system shall include all the equipment necessary to allow acquisition and recording of seismic data within the requirements of the specification.

3.1.1 General Description: The basic component of this system is the analog/digital data acquisition control unit.

This system shall have the capability of operating with both digital magnetic tape recorders and graphic printers and shall provide the option for using both types of recorder simultaneously or either type singly. It shall also have the capability of being expanded to include a dual magnetic tape transport system. The system shall have capability of being operated in continuous mode.

3.1.1.1 Data Acquisition Control Unit: The data acquisition control unit shall acquire a minimum of 4 channels of seismic data, with expansion capabilities to at least 24 channels; it shall also have a minimum of 4 auxiliary data channels. It shall have the capability of accepting signal from such analog sensors as hydrophones and geophones, amplifying the signal to necessary levels, bandpass and band-reject filtering the signal, digitizing it, performing on-line processing, formatting the signal, and storing it in a buffer memory. It shall then be able to record the data on magnetic tape in SEG-D format on 9-track, 6250 bpi, 10-1/2 inch reel tape recorder systems. Also, using read-after-write and, if required, digital-to-analog (D/A) conversion, the system shall display the data on a cathode ray tube (CRT), provide on command a hard-copy printout of the CRT display and/or buffer memory, and print the data on a dot matrix printer in transverse "line scan" mode in the form of "wiggly lines." The acquisition control unit shall have built-in system test and diagnostic capabilities (including electronics, hydrophone/geophone cables, hydrophones/geophones, tape recorders, and signal source controls). All controls shall be front panel mounted or keyboard controlled.

3.1.1.2 Graphic Display. A capability must be provided for displaying the digital data in graphic line scan recording (LSR) ("facsmile") format and printing a permanent hard copy. This output is required to provide real-time monitoring and verification of data quality and to allow underway seismic interpretation and system parameter modification. Graphic display shall be available both before and after any signal processing operations in the

system. The graphic display shall be shot-break synchronized, transverse sweeping, wiggly line or variable area trace type (exemplified by such units as the Printronics, Versatec, and similar recorders). Any necessary automatic gain control or other interfacing processing shall be provided either internally or by interfacing microprocessor. An additional printer capable of making a hard copy of the CRT display and the buffer memories shall also be provided.

3.2 DETAILED SYSTEM DESCRIPTION

3.2.1 Analog

3.2.1.1 Channels. The system shall include a minimum of 4 channels, plus 4 auxiliary channels. However, the system must be expandable to at least 24 seismic and 4 auxiliary channels within the master acquisition control unit and to at least 48 seismic channels and 4 auxiliary channels by the use of expansion modules that accommodate additional analog, digitizer, and memory cards. All channels shall be under the control of the master data acquisition control unit.

3.2.1.2 Absolute Frequency Response. Frequency response shall be flat +3 dB for all sample intervals within specified frequency bands. For 1/4 msec sample interval this response shall be 5 Hz-1 kHz; for 1/2 msec, 5 Hz-500 Hz; for 1 msec, 5 Hz-250 Hz; for 2 msec, 5 Hz-125 Hz; for 4 msec, 5 Hz-70 Hz.

3.2.1.3 Total Harmonic Distortion (THD). THD shall be a maximum of 0.1% from 3 Hz to 1250 Hz at 0.25 V rms input with minimum preamp gain.

3.2.1.4 Input Noise. Input noise shall be a maximum of 0.5μV rms over the frequency range 3-1250 Hz with the input terminated in a 700-ohm source with maximum preamp gain.

3.2.1.5 Input Impedance. The input impedance shall be a minimum of 20,000 ohms differential mode and 5,000 ohms common mode.

3.2.1.6 Preamp gain shall be selectable over the range of 12-42 dB inclusive. Gain steps shall be a maximum of 6 dB.

3.2.1.7 Level Monitor. Some mode of indicating peak recording level on a selected channel shall be provided. The channel selection shall be by a front panel or keyboard control.

3.2.1.8 Common Mode Rejection. The common mode rejection ratio shall be a minimum of 75 dB over 3-1250 Hz at maximum preamp gain.

3.2.1.9 Low Cut Filter. The low cut filters shall have front panel or keyboard selectable cutoff frequencies and slope. Cutoff requirements shall be selectable over the range 5-300 Hz with a minimum of 16 possible cutoff frequencies in this range. Filter slope shall be at least 18 dB/octave.

3.2.1.10 Anti-Alias Filter. The anti-alias filter shall have a minimum of 6 front panel or keyboard selectable cutoff frequencies, with the maximum cutoff frequency at 1400 Hz, 6 dB corner. The anti-alias filter slopes shall be a minimum of 78 dB/octave.

3.2.1.11 Notch Filter. The notch filter shall be front panel or keyboard selectable. It shall provide a minimum of 60 dB of rejection at 60 Hz.

3.2.2 Digital.

3.2.2.1 Analog to Ditigal (D/D) Conversion. A/D conversion shall be accomplished by an A/D converter preceded by an Instantaneous Floating Point (IFP) Amplifier. Multiplexed or demultiplexed format must be an operator selectable option.

3.2.2.1.1 A/D Converter. The A/D converter shall convert a minimum of 14 bits plus sign (15 bits including sign).

3.2.2.1.2 IFP Gain. Gain range shall be a minimum of 96 dB in 6 dB steps. The IFP gain for any channel shall be independent of the IFP gain of any other channel.

3.2.2.1.3 Gain Frequency. Gain step to gain step error shall be a maximum of 0.1% from 0 to 66 dB gain. Gain error between channels at minimum preamp gain shall be a maximum of 2%.

3.2.2.2 Time Base. Time standard error shall be a maximum of +0.002% (one part in 50,000) from 0 to 50°C.

3.2.2.3 Linearity of Conversion. Conversion linearity shall be 0.02% + 1/2 LSB (least significant bit) at DC or better.

3.2.2.4 Sample Rate. The sample rate shall be front panel switch or keyboard selectable at 1/4, 1/2, 1, 2, and 4 msec sample intervals.

3.2.2.5 Channels. Channels to be digitized shall be front panel switch or keyboard selectable.

3.2.2.6 Record Length. The record length shall be at least 16,000 samples long (at least 4 sec of seismic data at 1/4 msec sample interval), and the record length shall be controllable from the front panel or keyboard. Record delay shall be switch or keyboard selectable from 0 to 10 sec.

3.2.2.7 Tape Format. The digitized data shall be recorded on 10-1/2 inch diameter reel, 1/2-inch digital magnetic tape with 9-track, 6250 BPI, phase-encoded (PE) format.

3.2.2.8 Data Format. Data shall be stored on tape using SEG (Society of Exploration Geophysicists) Format D as outlined in Digital field tape format standards: SEG-D, compiled by the SEG Technical Standards Committee, Subcommittee on Digital Tape Formats.

3.2.2.9 End of File. A front panel or keyboard control shall be provided to write an end-of-file mark on the digital magnetic tapes.

3.2.2.10 Backspace. A front panel control shall be provided to allow backspacing the digital tape by one record.

3.2.2.11 Search. A front panel control shall be provided to enable searching of the digital tape in either forward or reverse directions for specific records.

3.2.2.12 Record Number. Front panel or keyboard control shall be provided for setting the initial record number and for setting the search record number. A front panel or CRT display shall be provided to indicate the current record number.

3.2.2.13 Start/Stop. Front panel or keyboard controls for starting and stopping acquisition shall be provided. Acquisition shall halt only at the end of the current trace or record.

3.2.2.14 Header. All header data identification constants shall be entered from front panel or keyboard controls.

3.2.2.15 Playback. Provision for playing back recorded data from digital magnetic tape shall be provided. Fixed gain and automatic gain control (AGC) modes of playback shall be selectable from front panel or keyboard. The playback channels shall be selectable from front panel or keyboard.

3.2.2.15.1 Fixed Gain. There shall be a front panel or keyboard control for selecting the gain in fixed gain, or fixed binary point, playback mode.

3.2.2.15.2 Automatic Gain Control (AGC). There shall be a front panel or keyboard control for selecting the length of an AGC window in playback mode. Window length must be adjustable from 1 sample to at least 1000 samples. Trace size shall be adjustable from front panel or keyboard.

3.2.16 Monitor. Provision shall be made for monitoring all channels, with fixed gain or AGC mode optional. Front panel or keyboard selection of channels and gain mode of monitored data shall be provided. The available sources will be the raw data directly from the IFP amplifier and the tape recorded data either from the read-after-write heads of the digital tape transports or from the system random access memory (RAM).

3.2.2.17 Tape Transports. The digital tape transports shall be capable of recording 6250 BPI, phase-encoded data on 10-1/2 inch reel diameter, 1/2-inch wide digital magnetic tape. The controller shall automatically switch transports to prevent loss of data when operating with multiple drives. Full tapes shall rewind automatically.

3.2.2.18 Energy Source Interface. Interfaces and programmed timing sequences shall be provided for interface to sparker, air gun, water gun, and explosive charge energy sources. All interfaces that are to contact closure shall be TTL level.

3.2.3 Error Indication

3.2.3.1 Tape Error. A front panel or CRT indication shall be provided to indicate an error in the tape transport that would prevent recording of data.
3.2.3.2 Data Indicator. A front panel or CRT indication shall be provided to indicate when data is actually being recorded.

3.2.3.3 Analog Error. A front panel or CRT indication shall be provided to indicate an error in setup of the analog section which would prevent recording of proper data.

3.2.3.4 Digital Error. A front panel or CRT indication shall be provided to indicate an error in setup of the digital section which would prevent proper

recording of data.

3.2.3.5 Tape Parity Error. A front panel or CRT indication shall be provided to indicate errors in data being read from/to the digital tape transport.

3.2.3.6 Startup inhibit. The listed error conditions shall inhibit operation of the system until the error condition is resolved.

3.2.3.7 Override. An easily accessible switch shall be provided to allow data to be recorded when a fault condition exists.

3.2.4 Self-test. Built-in tests for verification of proper operation and trouble shooting shall be provided.

3.2.4.1 Voltage Test. Front panel or CRT indicators shall be provided to allow monitoring of internal voltages.

3.2.4.2 Continuity Test. Front panel controls and indicators shall be provided to allow measurement on each channel of continuity of cabling from received devices connected to the system.

3.2.4.3 Filter Test. Built-in tests shall be provided for measuring uniformity of the filters.

3.2.4.4 Noise Test. Built-in tests shall be provided for measurement of input noise.

3.2.4.6 A/D Linearity Test. Built-in tests shall be provided for measurement of A/D linearity.

3.2.4.7 Cross-feed Test. Built-in tests shall be provided for measurement of amplifier cross-feed.

3.2.4.8 Gain Accuracy Test. Built-in tests shall be provided for measurement of amplifier gain accuracy.

3.2.5 Calibration. Provision shall be made for on-ship calibration of the A/D converter, IFP Amplifier, and Preamplifier. Complete and detailed instructions shall be provided in the system documentation.

3.2.6 Power. The Seismic Survey System shall operate from 12 ± 0.5 V DC power and shall have a power supply capable of producing suitable system power from $115 \pm 5\%$ VAC.

3.2.7 Environmental. The Seismic Survey System shall be able to operate in ambient temperatures of 0-40°C and in humidities up to 90% relative humidity.

3.2.8 Manuals. Three complete sets of operation and maintenance manuals shall be provided.

3.2.8.1 Tape System Parts List. A list of all components required for the operation of the system with a dual magnetic tape system and a dot matrix graphic printout system shall be provided.

3.2.8.2 Expansion Parts List. A list of all components required for increasing the number of channels shall be provided.

3.2.9 Spare Parts. A spare parts kit will include all major subassemblies such as electronic and mechanical subassemblies, display modules, power supplies, printed circuit boards, etc., required to support the system for 2000 hours of operation. The spare parts shall be selected by the vendor and shall be delivered with the system.

3.2.10 TRAINING

3.2.10.1 Training. The contractor shall conduct an operation/maintenance course at the Naval Oceanographic Office, Bay St. Louis, NSTL, Mississippi. The course shall be for 25 people and shall include, but not be limited to, the following.

o Training shall be conducted by an experienced instructor who is qualified with the equipment and has demonstrated his capabilities to meet the requirements specified herein.

o The U.S. Government will provide training facilities and such aids as projector, paper, etc.

o The course shall not exceed 10 working days.

3.2.10.2 Operation. The contractor shall provide theory and hands-on demonstration/student participation of all operational characteristics of the equipment. The contractor shall provide documented results of each student's proficiency in operating the equipment.

3.2.10.3 Maintenance. The contractor shall provide troubleshooting to the printed circuit card or module level, repair methods (special to the equipment), alignment/calibration techniques and general care of the system. This shall be accomplished by demonstration/student hands-on performance. The contractor shall provide documented results of each student's understanding of training conducted.

3.2.10.4 Maintenance Manuals. The maintenance manuals shall include theory of operation, schematics, wire list to include cable runs, replacement parts listing to include part numbers of replacement parts and a second source for that part with part number, trouble-shooting guide, and calibration procedures.

3.2.10.5 Special-Purpose Test Equipment. Special purpose test equipment or special tools required to maintain the system should be provided by the vendor.

Appendix 2: Technical specifications for a hydrophone streamer array

APPENDIX 2: TECHNICAL SPECIFICATIONS FOR A HYDROPHONE STREAMER ARRAY

1.0 SCOPE

1.1 This document specifies the requirements for a hydrophone streamer array to be used with single and multichannel analog and digital seismic data acquisition systems. These systems will be used for both high-resolution multichannel and single channel seismic profiling.

2.0 APPLICABLE DOCUMENTS

2.1 Not applicable.

3.0 REQUIREMENTS

3.1 System Definition: The hydrophone array system (also called "hydrostreamer," "streamer," or "cable") shall operate from oceanographic vessels, both U.S. Navy and other, and will be used to collect single channel seismic reflection data (an operation also referred to as "continuous reflection profiling," "normal-incidence profiling," and "vertical reflection profiling") and high-resolution multichannel seismic reflection data. The system shall include all equipment necessary to receive seismic pressure waves and generate electrical analogs suitable for recording by standard seismic data acquisition systems within the requirements of the specifications.

3.1.1 General Description: The basic components of this system are the active sensor sections. These sections consist of plastic tubing, typically approximately 5-7 cm in diameter by at least 50 m long, which contain displacement, velocity, and acceleration-insensitive, pressure-sensitive hydrophones arranged in noise cancelling, signal enhancing groups. These groups are spaced with centers at intervals appropriate for the frequency spectrum of the seismic signal and the overall dimensions and geometry of the seismic experiment or survey section. The active sections also contain depth sensors and, located at selected points within the hydrostreamer, inductive coupling devices that communicate with auxiliaries attached externally to the hydrostreamer. The auxiliaries include hydrostreamer leveler devices and magnetic heading detectors, both of which also contain depth sensors. Full-length, insulated, twisted conductor pairs carry the signal from the hydrophone groups, depth detectors, and inductive couplers in the section (and in any other serially connected active sections) to the end of the section. At one end they are connected to a towing leader. The towing leader contains stress members to support towing forces and continuations of the signal conductor pairs. An elastic section between leader and active section cushions shocks encountered in towing. To the aft end of the active section a trailing section terminated in a swivel for attachment of a drogue is attached to complete the streamer assembly.

3.2 Detailed System Description

3.2.1 Active section: electrical characteristics

3.2.1.1 Hydrophones. Teledyne model T-2 or equal.

Sensitivity, free field voltage:
$20\mu V/\mu bar$ (-194 dB $\pm$ 1.5 dB re $1\mu V/\mu Pa$)

Sensitivity, free field charge:
320 nC/bar (-170 dB $\pm$ 2 dB re 1 $nC/\mu Pa$)

Depth, maximum allowable without damage:
at least 600 m.

Depth, maximum recommended operating:
approximately 200 m.

Resistance, minimum:
500 M ohms.

Capacitance, maximum:
$0.02\mu F \pm 5\%$.

Resonant frequency in ballast fluid:
4 kHz $\pm$ 5%.

Frequency response:
flat $\pm$ 3 dB from 15 Hz to 1350 Hz.

Sensitivity versus depth:
no greater than 3 dB variation between 0 and 200 m.

Sensitivity versus temperature:
no greater than 1 dB variation between 0°C and 30°C.

3.2.1.2 Groups. The hydrostreamer shall have the hydrophones arranged to form two independent, overlapped sets, each with its own sets of conductors. One hydrophone set shall consist of short "point arrays" of hydrophones. The second set shall consist of longer linear arrays. By external manipulations of the conductors, it shall be possible to arrange either set into at least three different 48-group streamer configurations ("48-channel" systems). The spacing shall be selectable external to the streamer.

3.2.1.3 Group interval. The configuration with "point array" groups shall have a closest spacing of 6.25 m between group centers. The second configuration shall have a smallest group interval of no more than 12.5 m. By skipping channels or by alternate jumper wiring, it shall also be possible to configure the streamer for longer intervals, especially at 25-m intervals. By paralleling groups it shall be possible to configure the streamer for single channel operation using up to 50 m of active section.

3.2.1.4 Hydrophone groups. The "point" groups (6.25 m group interval) shall consist of at least 4 hydrophones parallel wired to obtain a group length of no more than 0.2 m. The second set of hydrophones (12.5 m group interval, nominal) shall consist of at least 10 hydrophones in equally spaced arrays having element spacing of 1-1.2 m.

3.2.1.5 Conductors. The streamer shall contain conductor pairs for at least 100 channels of seismic data (two sets of 48 channels each plus auxiliaries or spares) and 7 depth sensors. Each conductor pair shall extend the entire length of the streamer section and shall be equipped with a connector at both ends to allow the catenation of stretch and active sections.

3.2.1.6 Electrical signal coupling. Coupling of hydrophones to preamplifiers shall be through transformers. The impedance characteristics of the hydrophone groups shall match a 10,000 ohm balanced-to-ground resistive preamplifier input (~20 K ohm total).

3.2.2 Active section: physical characteristics and construction.

3.2.2.1 Outer sheath. The outer sheath of the streamer shall be constructed of polyurethane tubing with an outside diameter of 6 cm $\pm$ 1 cm, with unpigmented walls of thickness 0.3 cm $\pm$ 0.02 cm.

3.2.2.2 Stress members. Stress members shall consist of three or more torque balanced wire rope members sufficient to withstand forces encountered in towing speeds of 14 knots with a 100 m hydrostreamer and of operating speeds up to 9 knots with a 1200 m streamer.

3.2.2.3 Ballast fluid. An odorless kerosene type with low sulphur, aromatics, and olefins content shall be selected to ensure integrity of active section components.

3.2.2.4 Fill/vent fittings. Each streamer section shall have at least one separate fill and one or two vent fittings as required for externally controlling liquid ballast volume and for purging entrapped gas.

3.2.2.5 End terminations. Bendix PTO 6A-24-6S, Cannon PTO 6A-24-61S, or equivalent.

3.2.2.6 Interconnection. Sections must be capable of interconnecting with other active sections, stretch sections, depth sensor sections, and towing leader to allow catenation of the system while maintaining water tight connections. Through connectors, conductor pairs shall pass the entire length of the hydrophone streamer assembly.

3.2.3 Depth transducers

3.2.3.1 Sensor type. Depth sensors shall be HP-107A, or equivalent variable reluctance transducers built into the streamer active sections with dedicated conductors.

3.2.4 Tail Assembly

3.2.4.1 Purpose. This section connects to the trailing end of the streamer assembly and serves to stabilize flow over the streamer, as well as providing a swivel attachment for a drogue.

3.2.4.2 Physical configuration and construction. Construction shall be conformable to that of Paragraph 3.2.1, except that the section shall contain neither sensors nor conductors.

3.2.5 Tow Leader.

3.2.5.1 Function. The tow leader tows the streamer behind the towing ship and serves to conduct the signals from the hydrophones, depth sensors, and inductive couplers to the data acquisition system and other appropriate units aboard the ship. It serves to make the transition from stretch/active sections of the streamer to a towing cable containing continuations of the signal

conductors and torque balanced stress members carried inside a sheath comprised of insulation and other protective jacketing. The cable is terminated into a deck leader, which makes the final connections with the appropriate channels in the acquisition and other systems.

3.2.5.2 Connectors. The aft end of the tow leader shall have connectors which are compatible with the mechanical and electrical connectors of the stretch and active sections to allow flexibility in streamer configuration and uses. The deck end of the tow cable shall be terminated in connector plugs compatible with, and easily detachable from, the deck leader to allow quick disconnection at the hydrostreamer winch. This capability will expedite retrieval of the cable in emergencies as well as facilitate normal operations.

3.2.5.3 Conductors. The tow leader shall contain conductor pairs to handle 50 seismic channels in all optional active section configurations as well as at least seven depth sensors. Conductors, in twisted pairs, shall be of at least 26 AWG, stranded, tinned, cadmium-bronze wire with at least 6 mil PVC insulation.

3.2.5.4 Stress members. Stress members shall be made of either stainless steel or galvanized improved plow steel. They shall be either a torque balanced central stranded cable surrounded by conductors or a two-layer, torque-balanced "armor" sheathing surrounding the conductor bundle. The tow leader shall be capable of withstanding a towing speed of 14 knots with a 100-m streamer, and of operating at speeds up to 9 knots with a 1200-m streamer.

3.2.5.5 Jacket. The tow cable jacket shall consist of polyurethane of approximately 2 mm thickness.

3.2.5.6 Length. The towing leader assembly shall be at least 100 m long.

3.2.6 Deck Leader.

3.2.6.1 Function. The deck leader forms the connecting link between the tow leader and the data acquisition system inputs. It runs from the deck of the ship to the seismic "doghouse" or to the ship's electronic instrumentation laboratory.

3.2.6.2 Physical configuration and construction. The deck leader shall have the same general construction as the tow leader towing cable except that a stress member is not required.

3.2.6.3 Connectors. The deck end of the deck leader shall be fitted with electrical connectors compatable with the tow leader and the various channel configurations of the active sections of the streamer. The laboratory end shall be fitted with plugs compatible with the inputs to the data acquisition system.

3.2.6.4 Deck lead length. The deck lead shall be $\sim$35 m long.

3.3 Spare Parts. Spare parts shall be selected by the vendor and delivered with the system. Spare parts sufficient to allow 2000 hours of normal operation and most non-catastrophic emergency repairs shall be provided with three copies of the parts list.

3.4 Maintenance Manuals. Three complete sets of manuals shall be supplied with the streamer system. They should include theory of operation, schematics, wire list to include cable runs, replacement parts listing to include part numbers of replacement parts and a second source for that part with part number, troubleshooting guide, and calibration procedures.

3.5 Special Purpose Test Equipment. Special purpose test equipment or special tools required to maintain the system should be provide by the vendor.

Appendix 3: Technical specifications for a hydrophone streamer depth monitor

APPENDIX 3: TECHNICAL SPECIFICATIONS FOR A HYDROPHONE STREAMER DEPTH MONITOR

1.0 SCOPE

1.1 This document describes the requirements for a depth monitor system to be used to determine the depths of special depth sensors located at selected points along the length of a hydrophone streamer system.

2.0 APPLICABLE DOCUMENTS

2.1 Not applicable.

3.0 REQUIREMENTS

3.1 System Definition. In reduction and analysis of multichannel marine seismic data, it is necessary to know with a good degree of accuracy what depth the individual receiver units happen to be beneath the surface of the water. The depth monitor system allows the determination of those depths. This system is a set of electronics required to convert the signals from depth sensors imbedded at selected points along the length of the hydrophone streamer and in the signal source(s) to depth readouts on a monitor displays. An auxiliary calibration unit is also included.

3.1.1 General Description. The depth sensors, which are integral parts of the streamer system and are described as such under the specifications for that system, are variable reluctance devices with electrical circuit characteristics responsive to absolute pressure. These transducers are supplied with conductors connecting them with the monitoring system in the laboratory. The monitoring system determines the depths of the sensors and provides direct readout of those depths on front panel displays. The calibration unit allows the depths to be corrected for offsets.

3.2 DETAILED SYSTEM DESCRIPTION

3.2.1 Monitor System: Electrical Characteristics

3.2.1.1 Transducer type. The system shall operate with variable reluctance type transducers such as the HP107A and equivalent devices. Coupling to the monitoring system shall be through transformers over balanced, twisted conductor pairs.

3.2.1.2 Conversion accuracy. The system shall give depths accurate within 1 m at any depth to 30 m for general purpose transducers and within 3 m at any depth to 120 m for deep tow transducers.

3.2.1.3 Transmission length. Maximum transmission length shall be at least 4000 m with conductor pairs not to exceed 28 AWG.

3.2.1.4 Linearity. Module circuitry shall include compensated logarithmic correction for transducer nonlinearity in recommended operating depth ranges.

3.2.1.5 Temperature stability. Variation of depth displayed shall not vary with temperature more than $\pm$ 0.03 m per degree Celsius.

3.2.1.6 Output. The system output shall be transistor-to-transistor logic (TTL) compatible binary coded decimal (BCD) with optional parallel or serial TTL analog from each module. This output shall be integrated into the SEG-D extended header.

3.2.1.7 Display. The depth display of each module shall be light emitting diode at least 1.5 cm high and at least 1-1/2 digits long.

3.2.1.8 Power. The system shall operate on 100-130 VAC, 50-60 Hz power.

3.2.2 Depth Monitor System: Physical Characteristics.

3.2.2.1 System configuration. The system shall consist of 12 depth readout modules to simultaneously display the depth at 12 points along the streamer active section, plus any chassis necessary for power supply, mounting of readout units, connection to transducer conductors,and printout.

3.2.2.2 Overdepth alarm. Audible and visual alarms that give warning when depths preset by the operator are exceeded shall be provided. The depths shall be front panel selectable by the operator and shall be silenced at the operator's option.

3.2.2.3 Printout. The depth monitor system shall be provided with a thermal line printer. The printer shall have an internal calendar and a clock, and shall be equipped with a programmable printout initiation timer plus a manual print and override capability.

3.2.2.4 Calibration unit. A field calibration device to calibrate the depth readout for the various transducers shall be provided.

3.2.2.5 Extender module. An module that extends the monitor readout units outside the chassis for accessibility for maintenance shall be provided.

3.2.2.6 Manuals. Three sets of manuals for the depth monitor system shall be provided with the system.

3.2.2.7 Spare parts. A kit of recommended spare parts for the system sufficient to operate for 2000 hours shall be included; three parts lists shall also be provided. Spare parts shall be selected by the vendor and shall be delivered with the system.

3.3 Special-Purpose Test Equipment. Special-purpose test equipment or special tools required to maintain this system should be provided by the vendor.

Appendix 4: Technical specifications for a water gun seismic signal source

APPENDIX 4: TECHNICAL SPECIFICATIONS FOR A WATER GUN SEISMIC SIGNAL SOURCE

1.0 SCOPE

1.1 This document specifies the requirements for a repetitive acoustic seismic signal source, or water gun, to be used with single and multichannel analog and digital seismic data acquisition systems. These systems will be used to collect both high-resolution multichannel data and single channel profiles (also called continuous reflection profiles, normal incidence profiles, and vertical reflection profiles).

2.0 APPLICABLE DOCUMENTS

2.1 Not applicable.

3.0 REQUIREMENTS

3.1 System Definition: The seismic signal source will operate from U.S. Navy and other oceanographic vessels and will be used in the collection of seismic and acoustic data. The system shall include all equipment necessary to generate impulsive signals used to acquire single and multichannel seismic or acoustic data within the requirements of the specification.

3.1.1 General Description. The basic component of this system is a pneumatic/hydraulic, impulsive signal generating device designated as a water gun. This device is discharged underwater and creates a pulse of compressional waves by using compressed air to drive a piston that forces a slug of water out of a cylinder into the surrounding water. The initial impulse of the escaping water, followed by the implosion of the vacuum left as inertia causes the escaping water to overshoot and cavitate, creates a short wave train with desirable broadband frequency characteristics. The water gun system consists of the water gun unit, a solenoid that triggers the firing of the gun, a firing box that activates the solenoid upon cue from the seismic data acquisition system or other timing device, a towing harness for carrying the water gun through the water, a compressed air supply hose and a used air vent hose, a solenoid activating cable, a shot break hydrophone, a gun signature hydrophone, a depth sensor, and conductors for shot break/gun signature hydrophones and depth sensors.

3.1.1.1 The water gun. The water gun shall have the following specifications:
- Piston (shuttle) displacement: 200 in^3 (3.3 L).
- Working pressure: 2000 psi (140 atm).
- Shot initiation: data acquisition system activated, solenoid-operated air valve.
- Mimimum firing depth: 1 m.
- Maximum firing depth: at least 500 m.
- Minimum cycling time: no greater than 8 sec.
- Minimum durability: at least one million pops, with only routine replacement of seals and springs and minor repairs, before requiring overhaul.

3.1.1.2. Signal characteristics. The water gun signal characteristics shall meet the following minimum specifications:

Peak signal pressure level: at least 5 bar-meters p-p, measured over 0-500 Hz.

Signal spectrum: flat within 20 dB from 20 Hz to 400 Hz, and within 40 dB to 1000 Hz (gun at 1-m depth, or more).

Signal pulse width: not more than 1000 μsec.

3.2 DETAILED SYSTEM DESCRIPTION

3.2.1 Water gun: electrical characteristics

3.2.1.1 Activating solenoid: The gun shall be discharged by an integral solenoid-operated air valve. The solenoid shall be energized by a 12-40 V pulse from a firing circuit that is controlled by the acquisition control unit or other external source.

3.2.1.2 Solenoid activating line: The water gun firing cable shall be CABLE-X, or equivalent, having maximum resistance of 0.4 ohms per 1000 feet. The line shall be 100 m long, with special watertight mating connectors between line and solenoid. Construction of the line shall be such that it is capable of withstanding the rigors of the pulse from the water gun. The main cable shall be connected to the solenoid through an approximately 5 foot long replacable "pigtail" made of CABLE-X or of more stress-resistant cable. The pigtail shall be connected to the main cable by a heavy-duty, waterproof, mechanical-shock resistant connector and to the solenoid by the special mating connector.

3.2.1.3 Water gun activating circuit: The water gun shall be discharged by a "firing box," which shall be a Bolt-type firing circuit (required to be compatible with presently owned equipment), which energizes a gun-activating solenoid upon signal from the data acquisition control unit. This unit shall provide a pulse of at least 12 V but not more than 40 V.

3.2.1.4 Shot break hydrophone: The time of each discharge of the water gun shall be monitored by a hydrophone operating in the near field of the outgoing signal pulse. This hydrophone shall be a Reed RGB-11C or equivalent designed to withstand the rigors of the high-stress mechanical operating environment. The hydrophone conductors shall be CABLE-X or equivalent cable. The shot break shall be recorded on the seismic data tapes.

3.2.1.5 Source signature hydrophone: The signal source signature of the water gun shall be monitored by a hydrophone operating within 5 m of the water gun discharge vents. This hydrophone shall be a Reed RGB-10C or equivalent. The hydrophone conductors shall be CABLE-X or equivalent cable. The source signature shall be recorded on the seismic data tapes.

3.2.1.6 Depth sensor: The depth of the water gun shall be continuously monitored by a depth sensor mounted on the gun or towing harness and operating through the hydrostreamer depth monitoring system. The depth sensor shall be a REF TEK or equivalent capable of operating in the high stress environment of the water gun and compatible with the hydrostreamer depth monitoring system.

Depth information shall be both visibly displayed and recorded on the data tapes.

3.2.2 Water gun: Mechanical Characteristics

3.2.2.1 Materials: The water gun shall be constructed of corrosion resistant materials such as hardened, stress relieved stainless steel, marine bronze or brass, or equivalent.

3.2.2.2 Finish: The finish shall be smooth machined surfaces.

3.2.2.3 Durability: The water gun shall be capable of withstanding normal heavy weather at-sea handling without damage. It shall be capable of being towed at high speeds (14 knots) without damage.

3.2.2.4 Compressed air line: The supply line for high pressure shall be nominal 1/2-inch Synflex or equivalent, 200 feet long. The air line shall have stainless steel connectors and fittings, JIC throughout, except that the air line may be connected to the water gun with a 1/2-inch JIC to 1/2-inch NPT adapter or similar arrangement. A replacable "pigtail" of high-pressure hose approximately 5 feet long shall be fitted between the main body of the air line and the water gun.

3.2.2.5 Air exhaust line: Air used to discharge the water gun shall be vented to the surface of the water through a nonkinking, rubber, air-hammer type hose of at least 1/2 inch inside diameter.

3.2.2.6 Towing attachment. The water gun shall have integral towing harness attachment points at both ends. Both of these points shall be individually capable of serving as the sole attachment point for the towing harness. The attachment points shall accept shackle bolts at least 1/2 inch in diameter.

3.2.2.7 Towing harness. The towing harness shall be constructed of flexible stainless steel wire rope at least 1/2-inch in diameter, with swaged-on stainless steel fittings. The gun shall be towed beneath a buoy, with depth adjustable from 1 m to 10 m. The main towing line shall be 100 m long, and will be Y-ed as necessary to tow both the water gun and a buoy large enough to suspend the water gun.

3.3 Spare parts. A kit of spare parts sufficient to allow 2000 hours of normal operation and most noncatastrophic repairs shall be provided by the vendor, with three copies of the parts list for the water gun system. The spare parts shall be selected by the vendor and delivered with the system.

3.4 Special tools. A kit of special tools that may be required to maintain and repair the water gun system shall be provided.

3.5 Maintenance Manuals. Three complete sets of manuals shall be supplied with the water gun system. Contents should include theory of operation, schematics, wire list to include cable runs, replacement parts listing to include part number to replacement parts and a second source for that part with part number, trouble-shooting guide, and calibration procedures.

3.6 Special-Purpose Test Equipment. Special-purpose test equipment or special tools required to maintain the system should be provided by the vendor.

Appendix 5: Specifications for an air compressor for marine seismic survey system

APPENDIX 5: SPECIFICATIONS FOR AN AIR COMPRESSOR FOR MARINE SEISMIC SURVEY SYSTEM

1.0 SCOPE

1.2 This document describes the requirements for an air compressor suitable for use aboard oceanographic vessels to provide high pressure ($P > 2000$ psi) air required for the operation of pneumatically powered seismic signal sources (air guns and water guns).

2.0 APPLICABLE DOCUMENTS

2.1 Not Applicable.

3.0 REQUIREMENTS

3.1 System Definition: The air compressor system shall operate from U.S. Navy and other oceanographic vessels and will be used to energize pneumatically powered seismic signal sources during underway high-resolution multichannel seismic profiling, continuous reflection profiling (CRP), wide angle reflection (WAR), ocean bottom seismometer (OBS), and other at-sea and undersea operations. The system shall include all the equipment necessary to provide high-pressure air for seismic signal sources normally used in such operations.

3.1.1 General Description: The basic component of this system is a multistage piston type compressor.

This system shall have the capacity of providing compressed air of quantity, pressure, and cleanliness adequate for operating air or water gun arrays used to collect marine seismic data. The design and construction of the system shall stress safety and simplicity of operation, durability and reliability, ease of maintenance and repair, portability, and reasonable compactness. It shall have the capability of operating continuously for long periods at both maximum and minimum capacities. It shall be capable of operating under heavy weather conditions and in conditions of high atmospheric moisture and salt content.

3.2 Detailed System Description

3.2.1 Compressor

3.2.1.1 Air pressure. The compressor shall be able to supply compressed, dried, filtered, cooled air at a pressure of at least 2500 psi at specified intake capacity.

3.2.1.2 Air intake capacity. The compressor shall have nominal atmospheric air intake capacity of 130-150 std ft^3/min (standard cubic feet per minute) at normal continuous operating speed.

3.2.1.3 Compressor operating speed. The compressor shall have a conservatively rated, extended continuous operation, normal speed of

approximately 600 rpm at nominal intake capacity. It shall have a maximum allowable operating speed of at least 800 rpm. It shall have a lowest allowable operating speed no greater than 300 rpm.

3.2.1.4 Compressor stages. The compressor shall have four stages of compression. To assure low stress on components, compression ratio between two consecutive stages shall not exceed 5:1.

3.2.1.5 Compressor cooling. The compressor shall have liquid bath (water-glycol) cooling of the cylinders. The cooling liquid shall be cooled by a radiator mounted integrally in the compressor system cage. For additional cooling, the compressor shall have an oil capacity of at least 15 gallons of oil.

3.2.1.6 Cooling of compressed air. Cooling of the air shall be provided after all four stages of compression. The heat exchangers shall be liquid (water-glycol) cooled. The cooling liquid shall be cooled by a radiator mounted integrally in the compressor system cage.

3.2.1.7 Overheat shutdown. The compressor shall have temperature sensors to detect overheating conditions. Overheating conditions shall result in the shutdown of the compressor.

3.2.1.8 Coolant loss shutdown. The compressor shall have coolant liquid sensors to detect loss of coolant. Loss of compressor coolant shall result in shutdown of the compressor.

3.2.1.9 Compressor lubrication. The compressor shall have a full internal lubrication system. Lubrication of the pistons and upper walls of the compressor cylinders shall be provided by the same internal lubrication system.

3.2.1.10 Intake air filters. All intake air shall pass through a low-restriction air filter, which will remove all particulate matter with an effective diameter greater than 5 μm. The filters shall have easily replaceable paper element filter cartridges of a type normally used with large internal combustion engines.

3.2.1.11 Moisture separators. Each stage of the compressor shall be provided with a moisture separator device that can be discharged during operation of the compressor. The final stage may be the compressor receiver tank.

3.2.1.12 Moisture discharge. The compressor shall be equipped with an automatic moisture separator condensate discharge. The discharge cycle shall be initiated periodically by a timing device with its own internal clock that is not subject to failure due to loss of outside power.

3.2.1.13 Moisture drain manifold. Condensate from the moisture separators shall be collected by a manifold and discharged through a muffler or other silencing device.

3.2.1.14 Safety valves. Each stage of the compressor shall be equipped with a device that allows discharge of excess pressure and that shuts down the compressor when pressure at that stage of compression becomes abnormally high.

3.2.1.15 Compressor mounts. The compressor assembly shall be mounted on a frame constructed of structural steel whose members shall consist of angles, channels, and/or I-beams with dimensions of at least 5 in X 5 in x 3/8 in thick. This frame shall also comprise the base of the compressor system cage.

3.2.2 Air Collector Tank

3.2.2.1 Collector tank capacity. The compressor system shall be equipped with an approved steel air receiver tank of at least 1.5 ft^3 feet capacity.

3.2.2.2 Collector tank working pressure. The collector tank shall have a normal working pressure rating of at least 4000 psi.

3.2.2.3 Collector tank pressure test. The collector tank shall be hydrostatically tested to at least 100% above normal working pressure, or to at least 4000 psi.

3.2.2.4 Pressure relief valve. The receiver tank shall be provided with a device that allows the relief of excess pressure. The discharge pressure shall be easily adjustable through external controls.

3.2.2.5 Moisture drain. The collector tank shall have a moisture drain located at its lowest point, which will allow complete drainage of condensate. It shall be drainable both manually and automatically during operation of the compressor without interrupting operation of the seismic signal source.

3.2.2.6 Mounting. The air collector tank shall be mounted within the compressor system cage, on the base frame, in a location providing easy accessibility from outside the cage.

3.2.3 Compressor power

3.2.3.1 Engine. The compressor shall be driven by a diesel engine of approximately 77 shaft horsepower. The engine shall be a General Motors GM 4-71 or equivalent in compactness and durability.

3.2.3.2 Engine cooling. The engine shall be equipped with a radiator that allows continuous full power operation in tropical temperatures. The radiator shall be mounted integrally in the compressor system cage. An engine-driven fan shall provide for circulation of cooling air over both engine and compressor radiators.

3.2.3.3 Overheating protection. The engine coolant temperature shall be monitored with an accurate, easily read, and accessibly located temperature gauge. An automatic engine shutdown feature that will stop the engine before damage occurs in case of loss of coolant or other overheating condition shall be provided.

3.2.3.4 Starting. The diesel engine shall be equipped with a compressed air starter. The use of air starters instead of electrical starters avoids the degeneration of electrical components that takes place in the highly saline operating environment and during long periods of storage.

3.2.3.5 Fuel. The compressor system shall be provided with an integral fuel tank of at least 100 gallons capacity, of which approximately half shall be available for consumption by the engine. At least 25 gallons shall remain in the tank at all times to ensure cooling of the fuel injectors. Alternate connections to use the ship's fuel supply shall also be available.

3.2.3.6 Clutch. The engine power takeoff shall be equipped with a dry disc clutch to provide neutral and engaged positions. Operation shall be with an easily and safely reached hand lever.

3.2.3.7 Power transmission. Engine power shall be transmitted to the compressor by means of multiple V-belts and pulleys that have ratios giving optimum operating RPMs for engine and compressor. The belts and pulleys shall be provided with a safety guard cage.

3.2.3.8 Crankcase oil pan. The engine shall be equipped with a baffled or extra-deep oil pan, which will allow the engine to operate in sea conditions of heavy rolling without loss of oil pressure.

3.2.3.9 Oil pressure gauge. The engine shall be equipped with an accurate, easily read, and accessibly located lubricating oil pressure gauge.

3.2.3.9 Crankcase oil drain. The engine shall be equipped with a readily accessible crankcase oil drain.

3.2.3.10 Muffler. The engine shall be equipped with a large and efficient muffler capable of reducing exhaust noise below 100 dBA measured at a distance of 15 feet. A removable exhaust pipe fitted with an efficient self-closing rain cap shall carry exhaust gasses to a height of at least 10 feet above deck.

3.2.3.11 Filters. The engine air intake shall be equipped with an efficient oil bath or dry paper element filter. The crankcase oil shall be filtered with a large-capacity, cartridge-type filter. The fuel shall have at least two stages of water removal and particulate matter filtering.

3.2.3.12 Engine mounts. The engine shall be mounted on a base frame constructed of structural steel members consisting of angles, channels, and/or I-beams measuring at least 5 in X 5 in X 3/8 in thick. This frame shall also comprise the base of a compressor system cage.

3.2.4 Compressor system base frame and cage.

3.2.4.1 Base frame. The base frame for the compressor system shall be constructed of welded structural steel members. Members shall consist of I-beams, channels, rectangular tubes and, in limited instances, angles having dimensions of at least 5 in X 5 in X 3/8 in thick. This frame shall be cross-braced, filleted, or boxed with steel plate. It shall carry provisions for mounting both engine and compressor, as well as air collector tank,

cooling system radiators, and a compressor system cage enclosing the entire system. Provision for adjusting drive belt tension and for securely bolting engine and compressor in position shall be made. The frame shall contain a sump or bilge to catch and collect leakage from the system and a drain or scupper to conduct the effluent to a holding tank or the ship's bilge. The frame shall not be longer than 8 feet or wider than 7 feet in outside dimensions.

3.2.4.2 System cage. The entire system shall be enclosed in a cage to consist of a frame of heavy wall tubing, bracing crossmembers, and expanded metal mesh. Corner members of the frame shall consist of nominal 4-inch, schedule 80 steel tubing or of 3-inch-square, 1/4 in wall square tubing. Crossmembers and bracing shall be no less than 2 in X 2 in channel or tube. The mesh shall be approximately 2 in square, of at least 1/8 in expanded steel plate. Doors and other openings shall be framed in 2 in X 2 in tube, channel, or angle.

3.2.4.3 Lifting/hold down eyes. Each upper corner of the compressor cage shall be equipped with an integral, welded-in lifting and hold down eye individually capable of lifting the entire compressor system with a safety factor of 2:1, or better. The cage frame shall be able to withstand such stress without failure or deforming. The eyes shall be suitable for either lifting the system or holding it fixed on a ship deck in heavy storm conditions.

3.2.5 Maintenance manuals. Three complete sets of operation and maintenance manuals shall be provided. They should include theory of operation, schematics, wire list to include cable runs, replacement parts listing to include part numbers of replacement parts and a second source for that part with part number, trouble-shooting guide, and calibration procedures.

3.2.6 Parts list. Three complete parts lists for the air compressor and accessories shall be provided. These lists may be exclusive of the diesel engine, but shall not not exclude such peripheral components and accessories provided by the vendor as controls, cooling system, fuel tanks and lines, and other items.

3.2.7 Drawings. Three sets of drawings of the system adequate for maintenance and repair of the compressor and peripherals and for identification of parts shall be provided, either separately or as part of the parts lists and manuals.

3.3 Spare Parts. Spare parts and expendables normally consumed in 2000 hours of operation shall be provided. A kit of vendor-recommended spare parts for repairs that can be made in the field shall be provided. The spare parts will be selected by the vendor and delivered with the system.

3.4 Special-Purpose Test Equipment. Special-purpose test equipment or special tools required to maintain the system should be provided by the vendor.

Appendix 6: Technical specifications for a hydrostreamer positioning system

APPENDIX 6

TECHNICAL SPECIFICATIONS FOR A HYDROSTREAMER POSITIONING SYSTEM

1.0 SCOPE

1.1 This document describes the requirements for a positioning system which controls the depth at which a hydrophone streamer tows, monitors the depth and magnetic azimuth at points along the streamer, and transmits the information to the instrument laboratory.

2.0 APPLICABLE DOCUMENTS

2.1 Not applicable.

3.0 REQUIREMENTS

3.1 System definition: The hydrophone positioning system shall operate from Naval and other oceanographic vessels and will be used in the collection of seismic data. The system shall include all the equipment necessary to allow control of hydrophone streamer depth and monitoring and recording of depth and towing azimuth (compass heading) within the requirements of the specification.

3.1.1 General Description: In the processing and analysis of marine seismic data, it is necessary to know with considerable accuracy both the depth of the individual receiver units (hydrophone groups) below the surface of the water and their position in the horizontal plane. Hydrostreamer leveler devices ("birds") and careful ballasting of the streamer allow control of the operating depth. Fluxgate magnetometer heading detector devices ("compasses") give the magnetic heading of segments of the streamer and allow determination of the streamer's general configuration behind the ship. Depth sensors in both the leveler and heading detector devices supplement the depth sensors built into the hydrostreamer and allow accurate determination of the depths of individual hydrophone groups. Commands from a control/display console setting the operating depths of the individual leveler devices are communicated to them through conductors and inductive signal coupling devices built into the hydrostreamer. Depth, bird vane angle, and heading information are returned through the same signal couplers and conductors to the recording laboratory, where the control/display console provides an interface with the data acquisition control unit and the system operator. There, the information is recorded on the data tapes and displayed for the operator.

The basic components of the system are the hydrostreamer leveler devices or "birds," the magnetic azimuth sensors or "compasses," depth sensors, a recording laboratory control/display console, and inductive signal couplers and conductors within the hydrostreamer.

3.1.1.1 Hydrostreamer Leveler Device/Depth Sensor: The hydrostreamer leveler shall be a device which uses movable planing surfaces, or vanes, and an internal control system to dynamically control the depth at which it moves through the water when it is towed. It shall be attached to the hydrostreamer by means of two collar clamp assemblies at least 1/2 meter apart which encircle the streamer and allow the device to hold that portion of the streamer at designated depth. Via conductors and coupling devices in the hydrostreamer, it shall receive instructions from a control console in the recording laboratory designating the depth to run, and it shall maintain that depth within narrow bounds. The bird shall have sensors which transmit depth and vane inclination information to the console.

3.1.1.2 Hydrostreamer Heading/Depth Sensor: The hydrostreamer heading sensor shall consist of a device which uses a fluxgate magnetometer to sense its own relative orientation to the horizontal component of the earth's magnetic field. This device shall be attached to the hydrostreamer by means of two collar clamp assemblies at least 1/2 meter apart which encircle the hydrostreamer and allow the device to determine the magnetic heading of that segment of the streamer. The device shall transmit that information to the control console via conductor pairs and coupling devices within the hydrostreamer. The device shall also contain depth sensors which transmit depth information to the console.

3.1.1.3 Hydrostreamer Positioning System Controller: The hydrostreamer positioning system shall have a controller unit located in the recording laboratory. This unit shall incorporate a phase encoded, frequency shift keyed (FSK) telemetry system with which to communicate with the streamer leveler and direction sensing devices. Through this telemetry system the unit shall control the depths at which the leveler devices are set to run. This unit shall also receive signals from heading sensors in the compasses, vane angle sensors in the birds, and depth sensors in both, converting these signals to visible readout on a console display and sending the information to the seismic data acquisition control unit to be recorded on magnetic tape and to line printer and dot matrix printers to provide realtime hard copy of the data.

3.2 DETAILED SYSTEM DESCRIPTION

3.2.1 Hydrostreamer Leveler Device: Mechanical Characteristics.

3.2.1.1 Dimensions. The leveler device shall consist of an elongated cylindrical body on the order of 1 m long and 6-7 cm in diameter with

horizontal diving planes or vanes attached near the aft end. The vanes shall span approximately 1/2 m and have a chord of approximately 1/4 m. The leveler devices shall be supplied with matched floatation chambers, selected so that a complete leveler device, including external battery pack, shall not weigh more than 2 kg in sea water.

3.2.1.2 Materials. The body of the leveler device shall be made of stainless steel and the diving planes of stainless steel, carbon fiber or fiberglass reinforced composite, or exceptionally durable, distortion-resistant thermoplastic such as ABS. Fittings and attachments shall be of stainless steel, or composite/plastic where required.

3.2.1.3 Operating range. The electronics compartment of the leveler device as well as all associated seals and mechanisms shall be capable of operating without leakage from the surface to a depth of 100 m.

3.2.1.4 Attachment to Hydrostreamer. The leveler device shall be externally attached to the hydrostreamer by clamping collars located near each end of the body and at least 1/2 m apart. These collars shall encircle the streamer at predetermined points corresponding to inductive signal couplers and bulkheads located inside the streamer. The collars shall be quickly and easily detachable to allow retrieval of the hydrostreamer on the winch but shall provide positive, loss free attachment. The collars shall also allow the streamer to rotate freely while the bird is held level. They shall also provide attachment points for the auxiliary floatation chambers on the side opposite the leveler device.

3.2.2 Hydrostreamer Leveler Device: Electrical Characteristics.

3.2.2.1 Diving plane activation. The operating depth of the leveler device shall be dynamically controlled by diving planes. The instantaneous angle of the diving planes shall be determined by battery powered servo motors.

3.2.2.2 Diving plane control. The servos setting vane angle shall be controlled by a microprocessor in the depth controller body. The microprocessor shall receive commands specifying operating depth from the control console via hydrostreamer conductors and inductive couplers. It shall then take depth data from strain gage depth sensors within the depth controller unit and use that information to dynamically maintain the specified depth within one foot. Vane angle shall be transmitted to the system controller console. To facilitate obstacle avoidance, the depth control system shall have two instantly accessable preset operating depths: surface, and full operating depth. The chosen position shall be accessed simultaneously in all birds on the streamer by a single keystroke at the system controller console.

3.2.2.3 Depth sensors. The depth sensors in the leveler device shall be of the strain gage type. They shall be self-zeroing and shall require no special field calibration. Depth information shall be supplied to the depth controlling microprocessor. Bird depth shall also be transmitted to the system controller console.

3.2.2.4 Battery pack. The leveler device electronics and servo mechanism shall be powered by an easily removable, quick change battery pack. The battery shall be either lithium or rechargable nickel-cadmium with separate charger. The battery shall have sufficient capacity to operate the bird continuously for a normal 3-week cruise leg with at least 20% reserve charge. The battery shall be contained in the shell of the bird or have its own external shell which will be pressure rated to full operating depth and configured to match the leveler device attaching collars.

3.2.2.5 Telemetering system. The leveler device shall contain all necessary electronics to allow communication with the system controller console. Telemetering shall be by frequency shift keyed, phase encoded, 27 hertz carrier tone. Transmission shall be via inductive coupling between bird and hydrostreamer and signal conductors in the streamer.

3.2.3 Hydrostreamer Heading Detector: Mechanical Characteristics.

3.2.3.1 Dimensions. The body of the hydrostreamer heading detector shall consist of an elongated cylindrical body not more than 1 m long and 10 cm in diameter. With cable attachment apparatus the device shall weigh no more than 2 kg in water.

3.2.3.2 Materials. The body of the device shall be made of stainless steel tubing. Fittings in critical stress applications shall be of stainless steel or bronze. In non-critical stress applications, they may alternatively be made of carbon fiber or fiberglass reinforced composite or of exceptionally durable, distortion resistant thermoplastic.

3.2.3.3 Operating range. The device shall be able to operate from the surface to a depth of at least 100 m.

3.2.3.4 Operating attitude. The azimuth sensor of the device shall be gimballed to allow 360° of roll and at least 20° of pitch both upward and downward from the horizontal.

3.2.3.5 Attachment to Hydrostreamer. The heading detector device shall be externally attached to the hydrostreamer by clamping collars located near each end of the body and at least 1/2 m apart. These collars shall encircle the streamer at predetermined points corresponding to inductive signal couplers and bulkheads located inside the streamer. The collars shall be quickly and easily detachable to

allow retrieval of the hydrostreamer on the winch but shall provide positive, loss free attachment. The collars shall also allow the streamer to rotate freely while the device is held level.

3.2.4 Hydrostreamer Heading Detector: Electrical Characteristics.

3.2.4.1 Sensor type. The direction sensor shall be a gimbal mounted, two-axis fluxgate magnetometer.

3.2.4.2 Sensitivity. The sensor shall have a full scale range of 60,000 gammas.

3.2.4.3 Resolution. The sensor shall be able to resolve a flux density difference of 50 gammas in the range 20,000 to 60,000 gammas.

3.2.4.4 Heading resolution. Directional resolution in the horizontal plane shall be no coarser than 0.2 degree.

3.2.4.5 Signal averaging. The magnetic field measurements shall be averaged with time constants variable in steps of X2. Selectable time constants shall include at least 2, 4, and 8 sec.

3.2.4.6 Power. The heading detector device shall be powered by an internal lithium or mercury cell battery.

3.2.4.7 Depth sensors. The depth sensors in the leveler device shall be of the strain gage type. They shall be self-zeroing and shall require no special field calibration. Depth information shall be transmitted to the system controller console.

3.2.4.8 Telemetering system. The heading detector device shall contain all necessary electronics to allow transmission of magnetic heading and depth data to the system controller console. Telemetering shall be by frequency shift keyed, phase encoded, 27 hertz carrier tone. Transmission shall be via inductive coupling between compass and hydrostreamer and signal conductors in the streamer.

3.2.5 Hydrostreamer Positioning System Controller: Mechanical Characteristics.

3.2.5.1 Unit packaging. The system shall be housed in heavy duty instrument cases, each module having flanges for mounting in standard 19-inch cabinet racks. This shall include the system control unit and CRT display modules.

3.2.5.2 Unit controls. The system shall receive depth setting instructions and other commands through a keyboard, either separate or integral to the system case.

3.2.6 Hydrostreamer Positioning System Controller: Electrical Specifications.

3.2.6.1 Power requirements. The system shall be powered by 115 +/-15 V, 47-63Hz AC. Total power requirements shall not exceed 500 watts.

3.2.6.2 System controls. The positioning controller system shall be microprocessor controlled, operating from instructions selected from menus by the acquisition system operator and from keyed in programming instructions. It shall be capable of individually addressing each leveler device and of setting the operating depth of that device. It shall be capable of receiving depth data from depth sensors in the leveler and direction sensing devices, vane angle data from the leveler devices, and azimuth data from the direction sensing devices. The system shall be capable of instructing or interrogating at least five units per second. To facilitate avoidance of submerged obstacles and of overtaking ships, the system shall also have provisions for simultaneously addressing all leveler devices on a single keystroke and instantaneously setting the leveler devices to either rise to the surface or dive to deepest operating depth. To suppress noise due to leakage and coupling problems, it shall be capable of programming the telemetry system to mute during recording times.

3.2.6.3 Telemetry. To provide communication between controller and streamer-mounted leveler and direction sensing devices, the positioning system controller unit shall be equipped with a telemetry system using frequency shift keyed (FSK), phase encoded, carrier tone with center frequency of approximately 27 KHz. This telemetry system shall operate over a passive signal transmission system within the streamer consisting of a conductor pair and inductive coupling devices which communicate with matching inductive couplers within the direction sensing and leveler devices.

3.2.6.4 Display. Depths, vane angles, and azimuth shall be displayed on two or more cathode ray tubes (CRTs) at least 12 inches in diagonal dimension. In particular, the realtime positiom of the streamer relative to the geographic shot line shall be plotted and displayed on the CRTs: as a minimum, this shall include a plot of indicated depths on one CRT and horizontal streamer configuration on a second CRT. System status, control menus, and other control instructions and functions shall also be exhibited on a separate CRT, which shall be at least 5 inches in diagonal dimension. Provisions shall also be made for realtime logging of streamer position data on a line or dot matrix printer.

3.2.6.5 Data recording. Provisions shall be made for the recording of depths, vane angles, and azimuths on the magnetic data tapes. These data shall be recorded in the extended headers of the SEG-D-formatted data blocks.

3.2.7 Environmental. The Hydrostreamer Positioning System Controller shall be able to operate in ambient temperatures of 0-40°C and in humidities up to 90% relatove humidity.

3.2.8 Manuals. Three complete sets of operation and maintenance manuals shall be provided. The manuals shall include theory of operation, schematics, wire list to include cable runs, replacement parts listing to include part numbers of replacement parts and a second source for that part with part number, trouble-shooting guide, and any necessary calibrating procedures.

3.2.9 Spare parts. A spare parts kit will include all major subassemblies such as electronic and mechanical subassemblies, display modules, power supplies, printed circuit boards, etc., required to support the system for 2000 hours of operation. The spare parts shall be selected by the vendor and shall be delivered with the system.

3.2.10 Special-Purpose Test Equipment. Special purpose test equipment or tools required to maintain the system shall be provided by the vendor.

Appendix 7: Technical specifications for a portable seismic recording laboratory (instrument van)

APPENDIX 7

GENERAL DESCRIPTION FOR A PORTABLE SEISMIC RECORDING SHELTER

Although this description of a custom portable instrument van is in the general format of a formal technical specification, these standards are to be regarded as tentative and suggestive. The reason is that it is anticipated that the van will be designed and constructed in-house by the Navy, using services and facilities at the Naval Ocean Systems Center (NOSC) in San Diego. At NOSC, a group of engineers and technicians led by Mr. Charles E. Hansen specializes in the design and construction of one-of-a-kind, highly specialized portable laboratory containers on a cost of labor and materials basis. The expertise and experience of this group in fabricating laboratory shelters specifically tailored for the oceanographic research environment is probably matched nowhere else; they have designed and built more than 100 vans for a wide range of applications. The specifications given here are a distillation of the experience of NORDA user-scientists in regard to the features found to be essential or desirable in such shelters and are given to serve as a guide the NOSC engineers in their design activities.

1.0 SCOPE

1.1 This document describes the requirements for a portable shelter assembly or van to provide work space for three persons and house a digital seismic data acquisition system that will be used aboard Navy and other oceanographic ships for obtaining single channel (continuous reflection profile (CRP)) and multichannel (wide angle reflection (WAR)) data.

2.0 APPLICABLE DOCUMENTS

2.1 Not Applicable.

3.0 REQUIREMENTS

3.1 System Definition: The shelter assembly shall be delivered as a completely assembled, pretested item of equipment, designed as an air/sea/land transportable unit, capable of housing electronic equipment and operating personnel in a controlled environment. The assembly shall be designed to operate tied down to the open deck of ocean-going survey ships.

3.1.1 General Description: The shelter shall be a closed, rectangular parallelopiped unit 20 ft long, 8 ft wide, and 8 to 8 1/2 ft high. It shall be constructed of rust-protected steel, and shall include supporting structure, reinforcements added to support electronic cabinets, and subsidiary structure required to support concentrated

loads. Welded construction shall be used wherever possible. The shelter shall be water and weather tight and shall provide internal climate control capable of maintaining standard laboratory temperature (70°, +/-5°F.) and humidity (RH < 75%) conditions from equator to poles.

3.2 DETAILED SYSTEM DESCRIPTION

3.2.1 General construction and strength. The shelter structure shall be of stressed skin design with internal framing providing space for thermal insulation on all walls and roof. The strength of the floors, walls, roof, and equipment support structure will be commensurate with the loading stress due to 10,000 pounds of electronic and support equipment to be installed in the shelter. The strength of the unit as a whole shall be at least equal to that of commercial shipping containers so that the van can be handled by commercial and military container-handling equipment and shipped on container ships and transport aircraft with minimal special requirements.

3.3 SHELL SPECIFICATIONS

3.3.1 Framing. Body framing structure shall include the following: Both outermost longitudinal members at the roof level shall extend the full length of the shelter and shall be utilized to join full-width roof bows. Vertical members shall be employed to combine the roof structure to the chassis frame. The corner posts shall be one piece, without splice, between the roof structure and chassis frame, and present corners on the shelter.

3.3.2 Shelter walls. The walls shall be constructed plumb and perpendicular to the adjacent sides. All walls shall be designed and constructed to withstand the environmental and loading forces specified. The outer skin shall consist of heavy-gauge panels welded or riveted to the wall structure. Each panel shall extend from beneath the roof capping to the edges of the floor frame. Where two panels join, the joint shall occur at a vertical structural member and the edges of one panel shall overlap the other. Highly rust resistant steel is the material of choice.

3.3.3 Shelter roof. The roof shall consist of heavy-gauge metal sheet covered with polyeurethane or similar synthetic rubber, and be supported by roof bows spaced on centers of 24 inches or less. The roof components shall be bonded to preclude panel vibration, and shall have the capability of supporting without damage the weight of several persons working atop the van. It shall also be capable of supporting several thousand pounds of distributed load without damage.

3.3.4 Shelter floor. The floor shall consist of a structural steel framework and substrate and plywood floor capable of supporting concentrated internal loads on the order of 1000 pounds per square foot without damage. External structure shall be such that the loaded shelter is capable of being handled from any point by fork lift without damage to the shelter. Slots for fork lift forks shall be provided

beneath the shelter floor, with all floor reinforcement necessary to prevent damage to the shelter also being provided.

3.3.5 Insulation. The floor, roof, walls, and door shall be provided with a lightweight, non-moisture absorbent, fire-resistant, vermin and fungus-proof insulation. The insulation shall be properly vented to prevent formation of ice during cold-weather operations. The roof shall be at least R 20 and the other sides at least R 12.

3.3.6 Doors. All doors shall be waterproof, air-tight, and dust-tight, even under heavy stress encountered during handling or in heavy seas. They shall be securely lockable and resistant to unauthorized entry. The personnel door shall be 30 inches by 78 inches and shall be centered on one end of the shelter. The door shall have hinges and latches interchangable from side to side, or be hinged on the left side facing inward.

3.3.7 Signal lead-in. Two 3-inch-ID cappable stuffing tubes shall be installed in the shelter. They shall be located approximately 12 inches above the floor and approximately 12 inches from the personnel door on 6-inch centers.

3.3.8 Exterior finish. The shelter exterior shall be galvanized and/or zinc flame sprayed steel, primed with at least two coats of epoxy primer, and painted with at least two coats of white epoxy or polyurethane paint.

3.3.9 Container handling and tie-down. There shall be provisions to allow the shelter to be lifted without damage by fork-truck and by crane. A lifting/tie-down ring shall be provided near each of the four corners on both sides of the shelter. Each of these eight lifting/tie-down rings shall be rated at no less than 20,000 pounds capacity. The shelter structure shall be adequately strong to be lifted fully loaded without spreaders by either the top or bottom rings without damage. Lift fork slots to accomodate fork lifting without damage shall be provided under the floor of the van.

3.3.10 Ground handling. The shelter shall be provided with a ground handling dolly to facilitate staging and storage of the shelter. The dolly shall consist of receptacles built into the floor of the shelter which accommodate detachable individual wheel units, or casters, with at least 12 in rubber tired wheels capable of handling the loaded shelter.

3.3.11 Weather resistance. The shelter shall be capable of withstanding 125-knot winds and the green-water deckwash conditions that accompany them without damage.

3.4 INTERIOR SPECIFICATIONS

3.4.1 Interior walls. The interior walls shall be lined with fire retardant plywood and an acoustically absorbent covering or with perforated aluminum alloy, 0.050 inch thick, with 1/16 inch diameter

holes at 1/8 inch on center staggered. The lining shall be applied to the walls and ceiling so as to retain a flat surface without deformation between framing members.

3.4.2 Instrument and instrument rack attachment; walls. All walls shall have two 1/4 inch X 6 inch tapping plates or equivalent attachment devices center located 60 inches and 30 inches above the floor. The door is excluded.

3.4.3 Floor. Floor panels shall be constructed of fire-resistant, water-resistant plywood at least 3/4 inch thick supported by steel structural members and substrate and covered by heavy-duty linoleum.

3.4.4 Instrument and instrument rack attachment: floor. There shall be two pairs of 1/4 inch X 4 inch tapping bars located in the floor. The bars shall run the full length of the shelter, one pair on each side. The outermost bar of each pair shall be 3 inches from the wall and the pair shall be 18 inches center to center.

3.4.5 Shelter headroom. The ceiling shall be 7 feet 3 inches, +/- 6 inches, above the floor.

3.4.6 Shelter lighting and air handling. The shelter interior shall be equipped with the quantity and arrangement of ceiling-mounted, incandescent light fixtures required to provide proper intensity to the shelter working area. The light fixtures shall be recessed in a false ceiling air duct. Proper grills, dampers, etc., will be provided. The air duct bottom shall consist of acoustical tiles or other sound-insulating material.

3.4.7 Interior finish. The shelter interior shall be painted with a light-blue enamel.

3.5 ENVIRONMENTAL CONTROL SYSTEM

3.5.1 Climate control: general. A severe-service air conditioner/heater/dehumidifier system shall be provided and permanently installed in one end of the shelter. The cooling capacity of the system shall be at least 48,000 BTU at 125°F ambient and the heating capacity at least 48,000 BTU at -70°F ambient.

3.5.2 Controls. Automatic temperature and humidity control shall be provided. A mode selector switch shall be provided having "ventilation," "cooling," "heating," and "off" positions.

3.5.3 Heating. Heat pumps and/or electric heaters shall be provided, as necessary, for winter heating or summer reheating.

3.5.4 Air conditioning. The air conditioning or heat pump system shall have constant running compressors with hot-gas-bypass. It shall have non-overloading type circulating fans and shall be designed for maximum noise and vibration reduction. The circulated air shall be filtered. Filters shall have a minimum capacity of 80% efficiency for dust

particles of 5 microns and larger. Filters shall be removable for maintenance.

3.5.5 Climate control hardware. The environmental control system shall require only electrical power for proper operation. All associated motors, wiring, ducting, etc., will be sized to achieve proper environmental condition.

3.6 POWER DISTRIBUTION SYSTEM

3.6.1 Main power requirements. The shelter power distribution system shall be designed to accept two different incoming power sources. When operating at a shore facility, the shelter shall accept incoming 220 volt, 3-phase, 4-wire, 60 Hz Wye-connected power; when operating aboard ship, the shelter shall accept 440 volt, 3-phase, 3-wire, 60 Hz Delta-connected power.

3.6.2 Power distribution system. A power distribution panel shall be supplied with main breaker and subsidiary panels or breakers as required for the environmental control system. In addition, the power distribution panel and associated transformers shall be capable of supplying 100 amps to branch circuit breakers to supply 115 volt, 1-phase, and 220 volt, 1-phase to electronic equipment. Branch circuit breakers and easily accessible wiring shall supply outlets located at approximately 3-foot intervals around the length of the van walls.

3.6.3 Instrument power. Individual instrument cabinet racks installed in the van shall each be provided with an isolation transformer and a voltage and frequency stabilizer equivalent to the Behlman Engineering Corp. model 150-C-SM AC power supply.

3.6.4 Power input. Incoming power shall be connected to the shelter by means of a water-proof connector.

3.6.5 Power system standards. The electrical system shall be designed in accordance with the National Electric Code.

3.7 INSTRUMENT AND WORKSPACE

3.7.1 Instrument Cabinet Racks. Primary instrument mounting facilities shall consist of at least six cabinets which accommodate standard 19-inch rack mount instrument flanges. These cabinets shall be VENT RAK model no. VD-7000-99-1130 or equivalent, 24 inches deep and 74 inches high, with front mounting flanges drilled and tapped #10-32 in standard RETMA EIA pattern, and with rear doors mounted on lift-off hinges and with single point flush cup latches. Sides of the cabinets shall be removable and held in place by no fewer than six screwdriver or wrench activated toggles. The frame shall include three horizontal unistruts on each side of the cabinet. These shall have attached to them rear adapters for the mounting of roll out instrument slides. Each cabinet shall be provided with a multiple outlet strip or plug mold

approximately 5 feet long with at least 10 three-prong receptacles. These strips shall be rated for 20 amperes at 115 vac; the ground prongs shall provide a positive earth ground. Each cabinet shall be able to accommodate 750 pounds of equipment.

3.7.2 Cabinet Rack Shock Mounts. The cabinets shall be mounted on the built-in tapping bars on the right side (as seen through personnel door) of the shelter using modified or adapted proprietary 2K Series Isolation Mount System mounts and stabilizers as developed by Barry Instruments (Watertown, Mass.) and used throughout the Navy. They shall adjoin each other to form a unit and the unit shall be set away from the personnel door approximately 30 inchs to leave space for an attendant's chair next to door and wall.

3.7.3 Graphic Recorder Mounts/Storage Space. Opposite the cabinet rack unit, and set away from the end wall containing the personnel door by approximately 30 inches, a 9 ft long by 27 to 30 in wide mounting surface for line-scan or facscimile recorders (e.g.; the EPC or the Raytheon LSR/UGR series) shall be provided. This surface shall consist of 3/4 in plywood, or equivalent, mounted on sturdy braces at an angle of approximately 30 degrees from vertical atop a 9 ft long by 20 to 24 in wide by approximately 30 in high table. The table shall be comprised of a 3/4 in plywood panel with a wood framework and formica or polyurethane resin worktop afixed to the tops of three 26 1/2 in wide by 18 in deep by approximately 30 in high (exclusive of casters, etc.) multi-drawer toolboxes, or equivalent drawer arrangement. The space between individual toolboxes shall be provided with hinged and latchable doors to provide additional storage space. The drawers of the toolboxes shall be lockable. They shall also be fitted with brass turnbolts on both ends to prevent opening during operations in heavy sea conditions.

3.7.4 Work Tables/Storage Space. At least six linear feet of 36 in wide flat table top is needed for navigation and underway operations as well as to provide workspace for instrument maintenance and repair. This table space shall consist of smooth finished, wood framed, formica or polyurethane resin topped, 3/4 in plywood, or equivalent, fixed atop lockable, multi-drawer toolboxes which provide an approximately 36 in high pedestal. The drawers shall be fitted with brass or bronze turnbolts at both ends. The cabinets shall be adjacent to each other or the space bretween them shall be provided with shelves and hinged, latchable doors to provide storage space. Diligent effort shall be made to provide the maximum amount of table and storage space commensurate with allowing reasonable room for attendant personnel.

3.7.5 Instrument power. The cabinet racks shall each be provided with an isolation transformer and a voltage and frequency stabilizer equivalent to the Behlman Engineering Corp. model 150-C-SM AC power supply.

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The seismic data acquisition systems presently owned by the Naval Oceanographic Office (NAVOCEANO) and customarily used aboard NAVOCEANO ships, especially the AGORs, have been in service for at least 10 years, and in some instances for almost 20. The technology they are based upon is at least 25 years old. Technically, these systems are still capable of obtaining data of limited usefulness. However, since they lack the benefits of some near-revolutionary development that has taken place in so-called exploration-type seismology during the last quarter-century, the data collection efforts of the Navy laboratories such as the Naval Ocean Research and Development Activity (NORDA) are seriously compromised. This report describes a highly flexible, state-of-the-art seismic system that would incorporate most of the latest developments while retaining the desirable features of the old systems.

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